ρ^0 Interferometry in Ultra-Peripheral Heavy Ion Collisions

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ρ^0 mesons are copiously produced in ultra-peripheral heavy ion collisions. One ion can emit a photon, which fluctuates to a quark-antiquark pair which scatters off the second ion, emerging as a ρ^0, or the second ion can emit a photon which fluctuates and scatters from the first. These two possibilities are indistinguishable, and so they interfere. The two possibilities are related by a parity transformation, and ρ^0 are negative parity, so the interference is destructive and the cross section is[1]

$$\sigma = |A_1 - A_2 \exp(i\vec{b}\cdot\vec{p})|^2 \quad (1)$$

where A_1 and A_2 are the amplitudes for the two photon directions, $\vec{b}$ is the impact parameter, and $\vec{p}$ the ρ^0 momentum. At mid-rapidity, $A_1 = A_2$ and

$$\sigma \approx 1 - cos(\vec{b}\cdot\vec{p}). \quad (2)$$

Of course, $\vec{b}$ is unknown, and must be integrated over. With this integration, most of the interference cancels out, except for $p_T \ll \hbar/\langle b\rangle$, where the spectrum is suppressed; $\langle b\rangle$ is the median impact parameter. This is the primary region of interest.

Without interference, the spectrum dN/dp_T is determined by the form factor of the target nucleus, and is well fit as an exponential in $t = p_T^2$ (the longitudinal contribution to t is small compared to the transverse): $dN/dt \approx \exp(-bt)$ where b is related to the nuclear radius.

We study the interference by selecting a clean ρ sample, using events with exactly 2 charged tracks, with a $\pi\pi$ invariant mass between 550 and 920 MeV/c^2. We consider two samples, exclusive ρ^0, selected by the STAR topology trigger (2 back-to-back tracks), and ρ accompanied by nuclear excitation; the latter events have a smaller average impact parameter, and so the interference is visible at larger p_T[2].

Figure 1 shows the dN/dt for ρ^0 with rapidity $0.1 < |y| < 0.5$ accompanied by nuclear breakup. The region $|y| < 0.1$ is contaminated by cosmic rays, while for $|y| > 0.5$, the $A_1 \gg A_2$ and the interference is smaller.

Also shown are simulations with (in blue) and without (in green) interference, and the like sign background (in black). Without interference, $dN/dt \approx \exp(-bt)$. In contrast, the data shows a significant drop for $t < 0.015$ GeV^2, which matches the simulation that includes interference. This drop clearly shows the interference.

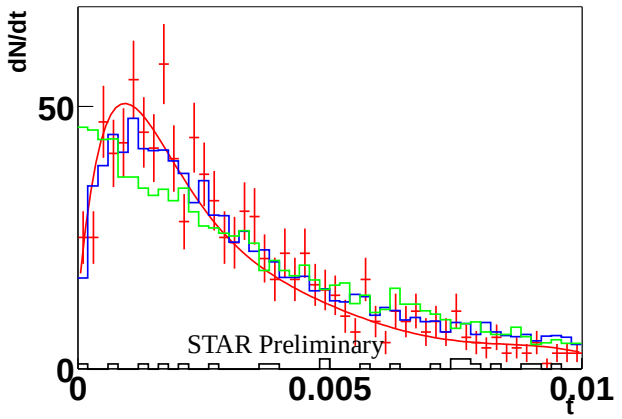

FIG. 1: Raw (uncorrected) dN/dt for ρ production in 200 GeV per nucleon gold-gold collisions. The red points are the data,blue is a simulation with interference, green a simulation without interference, and the black is the like-sign background.

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REFERENCES

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